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(54) Abstract Title: **Smoke detector with a low false alarm rate**

(57) An aerosol which enters a partly enclosed chamber 4 is sensed by increased signals from separated light scattering sensors A and B. These comprise sources 1 and 2 respectively combined with receiver 3, together with electronics means and signal processing in a microcomputer. Sensor A operates at visible wavelengths and sensor B in the near infrared, such that the relative signals are influenced by particle size and hence by the nature of the aerosol. Detection of a fire depends on correlating signals of sensors A and B, so as minimise the response to effects other than aerosols. The fire detection response threshold depends on the ratio of the signals of sensors A and B, and in some cases on the signal from a heat sensor, such as to improve the response to free-burning fires and minimise unwanted alarms resulting from aerosols not characteristic of smoke from a fire.

Figure 1

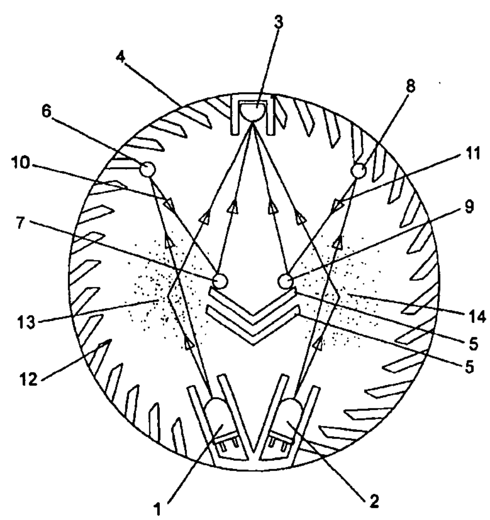

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Figure 1

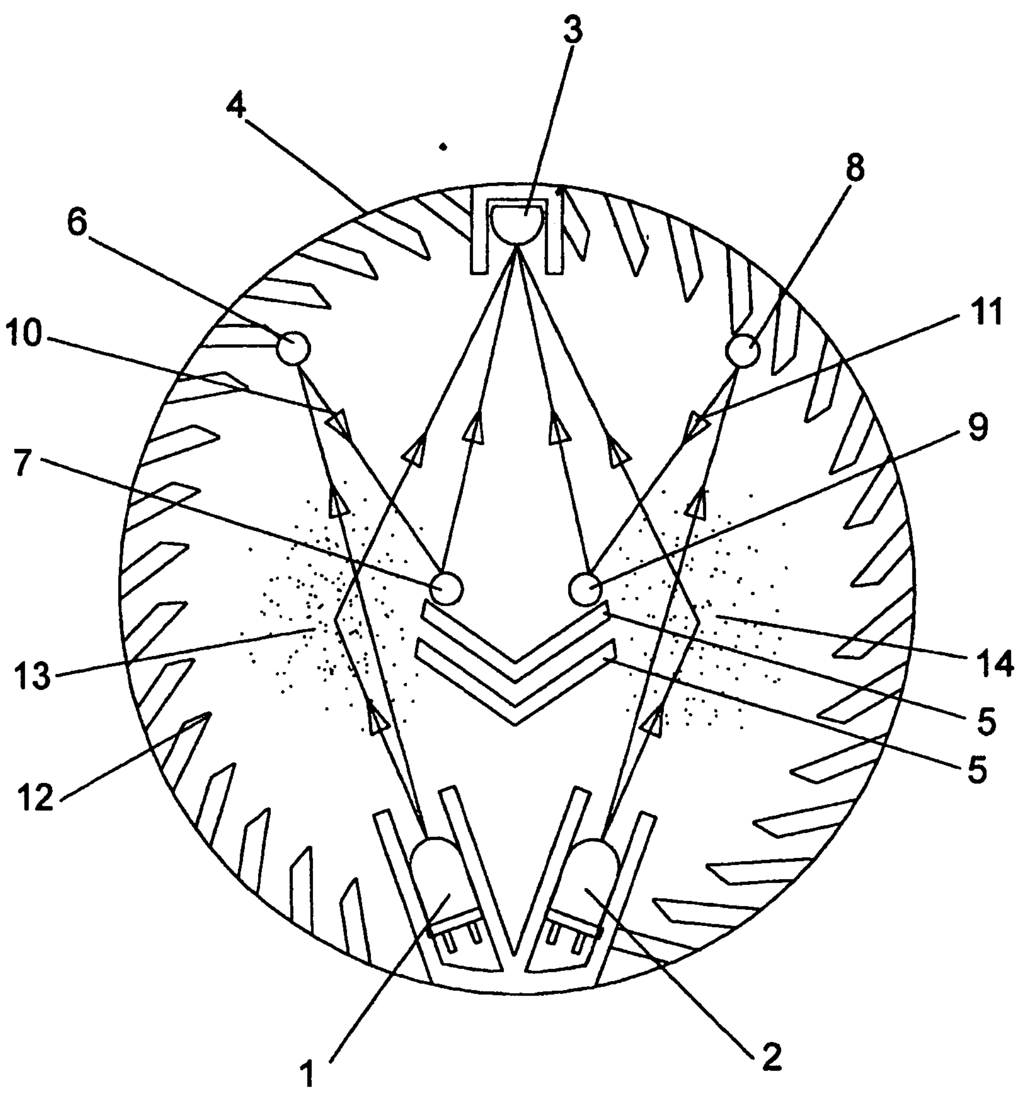
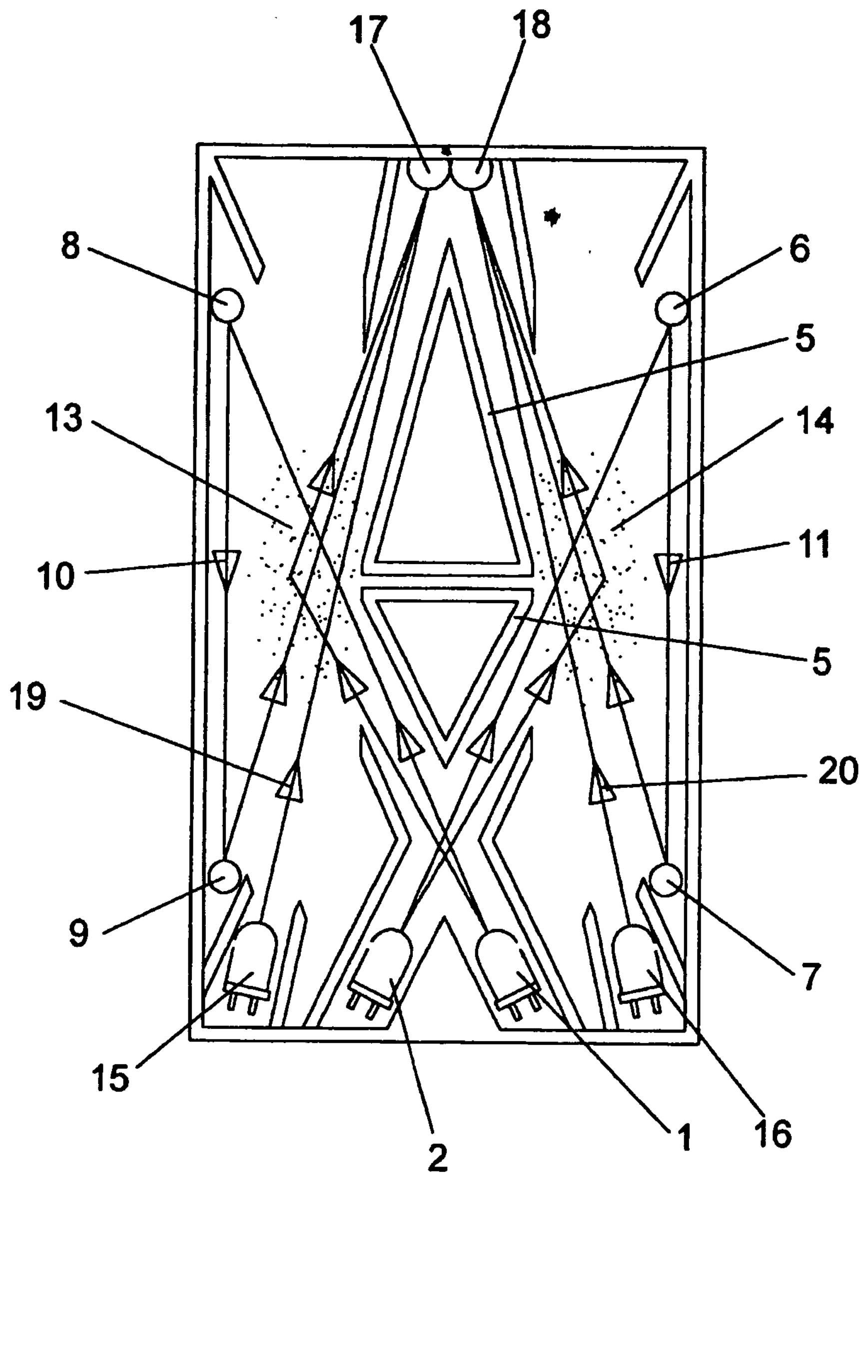


Figure 2



FIRE DETECTOR WITH A LOW FALSE ALARM RATE

This invention relates to an improved fire detector which senses the presence of smoke particles in air. It is well known that the presence of smoke may be sensed by means of the quantity of light which is scattered or reflected by smoke particles. Fire detectors based on this principle, often termed "optical smoke detectors", find widespread application as point fire detectors, which are generally mounted on the ceiling of a protected space where they sample part of any airflow driven by convection past the detector through a mesh and into a chamber. A light emitting diode source emits pulses of near infrared light into the chamber and scattered and reflected light reaches a receiver, generally a silicon photodiode or photo transistor, disposed so that it does not receive light from the source by a direct path. The signal at the receiver is due to light scattered or reflected by smoke particles (the smoke signal) which adds to that scattered or reflected by the mechanical features of the chamber (the quiescent signal), and the presence of smoke is sensed by an increase in the received signal. A common form of optical smoke detector employs a forward light scatter angle of typically 45 degrees and a light wavelength of approximately 900 nanometers (nm), and this is found to provide a good sensitivity, together with a convenient and low cost mechanical and electronic arrangement. A fire is detected if the smoke signal exceeds a given fire detection response threshold value, which is the smoke signal measured in a standardised oil mist aerosol having typically a light extinction coefficient of 0.15dB/m at 900nm.

There are several disadvantages with the common form of optical smoke detector. An increase in the received signal may result from factors other than smoke which increases the amount of light transferred from the light source to the receiver, and this can lead to false or unwanted alarms. There are a number of well known mechanisms for this, such as the presence within the chamber of reflective dust particles, fibres or small insects. It is not found to be practicable to totally prevent these from entering the chamber whilst still permitting sufficient airflow for the rapid ingress of smoke. Detectors of this type are also very sensitive to aerosols other than smoke, in particular to steam (droplets of condensed water in air), and this is also a cause of unwanted alarms. A further disadvantage is that the sensitivity is very dependent on the nature of the smoke, and this differs according to the type of fire. The highest sensitivity tends to be to light coloured smokes with a larger particle size, characteristic of smouldering fires. The lowest sensitivity is to smaller particles produced by free burning fires, and dark coloured smokes such as those emitted by burning hydrocarbons; indeed to just those types of fire which need to be detected most rapidly. Techniques are known to help overcome certain of the above disadvantages, for example by the inclusion of additional sensors, such as a heat sensor, a light extinction sensor, or an infrared light scattering sensor having a different scatter angle. However, these are not do not fully address all of the disadvantages.

It is an object of the present invention to provide for an improved optical smoke detector by means of a novel arrangement of low cost, reliable sensors, which combine to give a more even response to a range of fire types, and to minimise false and unwanted

alarms.

According to the present invention there is provided a fire detector wherein the presence of smoke which may ingress into a partly enclosed chamber is sensed by means of light scattered or reflected from smoke or other aerosol particles, characterised in that of any combination of sensors therein, two sensors each employ a light source, the emission wavelengths of these light sources being dissimilar, wherein signals from said two sensors are separately processed within a microcomputer or by similar means, such that the detection of a fire is conditional on there being some signal indicating the presence of smoke (smoke signal) from both of said two sensors, and such that the effective fire detection response threshold value and/or the time delay to alarm varies as a function of the ratio of the smoke signals of said two sensors, in a manner so as to vary the sensitivity of the fire detector to different types of smoke or aerosol.

The invention will now be described by way of example with reference to the accompanying drawing, in which figure 1 shows a first embodiment and figure 2 a second embodiment of a fire detector, showing the chamber and the optical arrangement.

As shown in figure 1, there is a chamber 4, into which smoke may ingress from the surrounding atmosphere through a mesh (not shown) intended to exclude most objects and insects. The assembly contains two light sources and one light receiver disposed substantially in a plane within chamber 4. Source 1 and receiver 3 constitute the opto-electronic components of a scattered light sensor A, and source 2 and receiver 3 the equivalent components of a scattered light sensor B. Light from source 1 and source 2 reaches receiver 3 by indirect paths through chamber 4, barriers 5 preventing light from reaching receiver 3 by a direct path from either source 1 or source 2. Features 6, 7, 8 and 9 are included which reflect a relatively predictable and stable quantity of light from source 1 to receiver 3 along path 10, and from source 2 to receiver 3 along path 11. The inner surfaces 12 of chamber 4 are made from dark coloured plastic and are provided with anti-reflection features, as would be known to one skilled in the art, such that the light from source 1 or source 2 which reaches receiver 3 as a result of scattering or reflection from said surfaces is significantly less than that which reaches it by path 10 or path 11. The amount of light which reaches receiver 3 from source 1 or source 2 is increased by scattering and reflection by smoke particles if these are present in sensing region 13 or 14 respectively. Source 1 emits at a wavelength in the visible part of the spectrum and source 2 emits at a longer wavelength in the near infrared part of the spectrum. Receiver 3 is sensitive to both wavelengths. A pulsed electrical current is passed through light sources 1 and 2 at different times in a given sequence by electronic means (not shown) controlled by a microcomputer, such that the quantity of light emitted by the sources is maintained in a substantially constant ratio. The output of light receiver 3 is amplified by electronic means (not shown) and the amplified output is monitored by the microcomputer coincident with the pulsing of each source, such that the signal received for sensor A and the signal received for sensor B may be separately analysed. The signal received in the absence of smoke or other aerosol is termed herein the quiescent signal of sensor A or the quiescent signal of

sensor B, and the increase in the signal resulting from the presence of smoke is termed herein the smoke signal of sensor A or the smoke signal of sensor B. It is preferred that for each sensor a time averaged value of the quiescent signal is calculated within the microcomputer, and that the signal increase from this baseline is used to calculate the smoke signal. If the time averaged values of the quiescent signals are calculated using a simple time constant, this time constant should exceed 12 hours, such that smoke signal values are not significantly affected in the event of a gradual increase in smoke concentration characteristic of a slowly developing fire.

A second embodiment of the invention is shown in figure 2. This includes the main features of the first embodiment, but in a slightly different arrangement. Associated with sensor A there is an additional light source 15, and with sensor B an additional light source 16. Also, associated with each sensor there is a separate light receiver: receiver 17 for sensor A, and receiver 18 for sensor B. Light from source 15 reaches receiver 17 mainly by direct path 19, and light from source 16 reaches receiver 18 mainly by direct path 20. Light sources 1 and 15 emit light at substantially the same wavelength. Light sources 2 and 16 also emit light at substantially the same wavelength, but longer than that for light sources 1 and 15. The inclusion of two light receivers 17 and 18 is not fundamental to the operating concept, but permits a convenient optical arrangement, and also that each light receiver may be optimised for light at the wavelength emitted by its associated light sources. Light source 15 acts as a reference source for sensor A, whilst light source 16 acts as a reference source for sensor B. Considering sensor A, a pulsed electrical current is passed through light source 1 and 15 in a given sequence, such that the quantity of light emitted by each source is maintained in a substantially constant ratio. The amplified output of receiver 17 is monitored by the microcomputer coincident with the pulsing of each source, such that a reference signal of sensor A is obtained, as well as a quiescent signal and a smoke signal of sensor A as described for the first embodiment. Equivalent signals of sensor B are similarly obtained. The reference signal of each sensor is used within the software of the microcomputer to calibrate the smoke signal of each sensor. One consequence of this is that the smoke sensitivity and/or the long term stability of sensor A and of sensor B may be increased as compared with that of the first embodiment. A preferred method whereby a reference light source may be used in conjunction a main light source to realise a proportional light scattering sensor is disclosed in UK Patent GB2273769.

It will need to be understood that the scattering and reflection of light by smoke is a complex phenomenon, and the relative importance of the various mechanisms depends on several factors. For the main scattering mechanism it is known that for a given range of particle sizes the amount of scattering is proportional to the particle density and the inverse fourth power of the wavelength of the light. The amount of reflection is dependent on the particle density, size, and the reflectivity at the light wavelength. A diverse range of particle sizes and other properties is found in smoke from a given type of fire, and this can vary during the course of fire development, and as smoke ages. In general, free burning (high temperature) fires produce a large proportion of very small (< 0.1μm in diameter) particles, whilst smouldering fires produce larger particles

(typically 1μm in diameter). Point smoke detectors are covered by the standard BSEN54-7:2001, which requires compliance with a series of standard fire tests (TF2 to TF5). These are not representative of all types of real fire, but do provide an objective measure of performance. The aforementioned common form of optical smoke detector performs satisfactorily for light coloured smokes with larger particles characteristic of smouldering fires in materials such as wood (TF2) or cotton (TF3), and performs less satisfactorily for dark coloured smokes such as those emitted by burning polyurethane foam (TF4) or hydrocarbons (TF5). Further, the performance in a free burning wood fire (e.g. TF1 of EN54-9) is relatively poor. In practice, the amount of light scattered or reflected from various types of smoke and other aerosols is found to be dependent on the wavelength of light, in the range 500nm to 1000nm. The following table gives typical values for the ratio of the smoke signals of two forward scatter light sensors similar to sensor A and sensor B of the first embodiment, sensor A having a red light source (peak wavelength of 626nm) and sensor B an infrared light source (peak wavelength of 880nm). Ratios are given for different fire types and also for two false alarm sources, cigarette smoke and steam. The relative sensitivities have been normalised to 1.0 for an oil mist aerosol similar to that specified for testing smoke detectors in BSEN54-7:2001.

free burning paper (blue smoke)	1.9
cigarette smoke	1.8
free burning polyurethane foam (TF4)	1.3
heptane fire (TF5)	1.2
smouldering wood (TF2)	1.0
smouldering cotton (TF3)	1.0
steam	0.35

According to a feature of the invention the smoke signals of sensor A and sensor B are individually processed and the fire detection decision is based on the ratio of the smoke signal of sensor A to that of sensor B, as well as on the absolute size of the smoke signal of one of the sensors, preferably the smoke signal of sensor B. This processing has the effect of modifying the sensitivity of the fire detector to different types of smoke or aerosol. In its simplest form, the software processing in a microcomputer modifies the fire detection response threshold value and/or the time delay to alarm, based on linear functions, but it will be understood that the fire detection algorithm could involve more complex mathematical relationships. It will also be understood that other factors, e.g. the temporal properties of the sensor smoke signals and/or signals from other sensors incorporated in the fire detector, may be taken into account in the signal processing. Such signal processing could be carried out by means other than a microcomputer, such as an application specific integrated circuit using linked analogue elements, or a digital signal processing circuit. The signal processing would be optimised to take into account physical properties of the fire detector, e.g. the smoke entry characteristics, so as to achieve the best compromise between effective fire detection and the rejection of false alarms. This could involve the inclusion of more than one sensitivity grade, which may be selected either manually or automatically so as to render the fire detector more appropriate to the specific fire detection application

and/or to the environment in which it is installed. It will be understood that a significant quantity of smoke or other aerosol may exist in certain real fires and in potential false alarm incidents, and it is important that the smoke signals of the sensors do not saturate before a valid smoke signal ratio is established. In order to fully realise the advantages of the invention the sensors will need to have a dynamic range greater than is commonly used in optical smoke detectors (e.g. a linear operating range greater than an equivalent light extinction coefficient of 1.0dB/m at 900nm).

It will be observed from the aforementioned table of normalised smoke signal ratios that the smoke signal ratio tends to increase the more free burning the fire. According to a further feature of the invention, in the event that the smoke signal ratio exceeds some value (e.g. 1.2), the fire detection response threshold value and/or the time delay before a fire is detected is progressively reduced up to some upper limit (e.g. 2.0). The effect of this will be to make the fire detector respond more rapidly to free burning fires than would otherwise be the case. It will be noted that cigarette smoke gives a similar smoke signal ratio to that for a free burning paper fire, and it would be advantageous if these could be discriminated. A true free burning fire generates significant heat, and it is known that this may be sensed with the aid of a thermal sensor incorporated in the fire detector. According to a further feature of the invention, the detection of a fire is inhibited or delayed if the smoke signal ratio exceeds some value (e.g. 1.5), but no significant signal is sensed from the thermal sensor. A preferred form of thermal sensor employs a negative temperature coefficient thermistor with a small body mass, mounted within a part of the fire detector enclosure which is relatively open to the ambient atmosphere. Such a thermal sensor can be made sensitive to small increases in air temperature, e.g. 1 degree C, at low air speeds, e.g. 0.5 metres per second, as would be known to one skilled in the art. It will also be observed that a significantly lower smoke signal ratio is seen in the presence of larger, more reflective droplets of water characteristic of steam. According to a further feature of the invention, in the event of a smoke signal ratio below some value (e.g. 0.6) the fire detection response threshold value and/or the time delay before a fire is detected is significantly increased. The effect of this case will be to make the fire detector respond less rapidly or not at all to steam.

According to a further feature of the invention the detection of a fire is conditional on there being some smoke signal from both sensors. Considering the first embodiment, sensor A and sensor B share a common chamber 4, which is partially separated by barriers 5. Air and smoke may flow freely between the two halves of chamber 4, but the partial separation makes it unlikely that a single object such as a fibre or an insect, or a spider's web, can simultaneously affect both sensing regions 13 and 14 so as to result in similar signal increases. For a given concentration of smoke or similar aerosol the smoke signal of sensor A and sensor B will tend to be in a constant ratio, at least over a time scale up to a few minutes over which the nature of smoke is substantially unchanged. A preferred approach which permits correlation in software in order to detect a fire is to employ coincidences in the temporal properties of the smoke signals, e.g. in the relative amplitudes of the frequency components and in the phases of these components. A relatively simple method whereby such temporal analysis may be

carried out is to generate time averaged values of the smoke signals of sensor A and sensor B within different time domains (e.g. using integration times from a few seconds up a few minutes), and to establish that the variation in the ratio of the averaged values over a short time is a small proportion of the absolute value of the ratio of the averaged values over a longer time. There are a number of equivalent known signal processing and statistical techniques whereby the same end may be achieved, and the exact method is not fundamental to the invention.

It is preferred that the light sources are light emitting diodes, such as GaAlAs semiconductor devices. The preferred emission wavelength for source 1 (or each of source pair 1 and 15) lies in the red part of the visible spectrum, e.g. a with peak wavelength at 626 nanometers (nm), and that for source 2 (or each of source pair 2 and 16) lies in the infrared, e.g. with a peak wavelength at 880nm. Suitable high efficiency components with an angle of emission of 15 degrees or less are available from a number of suppliers. It is preferred that each light receiver (3, or 17 and 18) is a silicon photodiode in conjunction with suitable amplification means. Silicon photodiodes operate efficiently at corresponding wavelengths and are widely available in suitable forms from a number of suppliers. There may be benefits in terms of discrimination of different aerosols were the wavelengths of the light sources to be more dissimilar. In the current state of the art the efficiency of light emitting diodes outside of the preferred wavelength range is found to be significantly reduced, and also silicon photodiodes are somewhat less sensitive. This presents practical difficulties at the present time in realising a working fire detector. By way of explanation of this point, the following table shows the relative smoke signals, in an oil mist aerosol, of light scattering sensors herein described using light emitting diodes having different light emission wavelengths.

880nm (infrared)	1.00
626nm (red)	0.48
590nm (amber)	0.11
473nm (blue)	0.02

It will be understood that in order to realise the advantages of the invention, the absolute sensitivity of each sensor, in a standard aerosol, needs to be calibrated for each newly manufactured fire detector. Means by which this can be achieved to a sufficient level of accuracy are well known, e.g. with the aid of a wind tunnel similar to that described in BSEN54-7. The invention relies on the ratio of the sensitivity of sensor A to that of sensor B remaining relatively stable during the operating life of the fire detector. This should be the case for a time period of at least one year, the expected time interval between in service cleaning or calibration, or the replacement of those components of the sensors which may be subject to changes in the properties of optical surfaces due to a build up air borne contaminants. It is preferred, at least in the case of the first embodiment that the such components are contained within a part which may be easily removed and replaced with the aid of a tool on the end of a pole.

In order to achieve stability it is important that the quantity of light emitted by given pairs of light sources, as heretofore described, are maintained in a substantially constant

ratio. Light emitting diodes convert electrical energy directly into visible or infrared light, the emitted intensity being approximately proportional to the electrical current which is passed through them. It is known that one variable which affects the light output for a given current is the temperature, the typical temperature coefficient at 20 degrees C being dependent on wavelength in the range –0.5% to –1.0% per degree C. The temperature coefficients are well matched for light sources of a given type and emission wavelength, and in the case of the second embodiment the ratios of the average pulse currents passed through light source pair 1 and 15 and though light source pair 2 and 16, may be controlled to maintain the ratio of light outputs over a wide temperature range. For the first embodiment, the emission wavelength of light source 1 is different from that of light source 2 and the ratio of the light outputs may not so closely follow the ratio of the average pulse currents. To improve the stability an adjustment may be made in software based on the output of a temperature sensor incorporated within the fire detector, which may employ the same sensing element as the thermal sensor heretofore described. A preferred method whereby the average pulse currents in a pair of light sources may be maintained in a constant ratio is similar to that disclosed for a light extinction sensor in UK Patent GB2267963. A first capacitor associated with a first source is successively charged with a given current for an accurately determined time, then is discharged through the source for a fixed pulse time. A second capacitor associated with a second source is successively charged with a near identical current for another accurately determined time, then is discharged through the source for the same fixed pulse time. The ratio of the charge times determines the ratio of the light outputs, irrespective of drifts in properties of the light emitting diodes and any associated electronics drive circuitry.

It is also important that the proportion of the emitted light which is transferred from light source to receiver by scattering and reflection in a given type and concentration of smoke remains in a stable ratio for the two sensors. The optical surfaces associated with the sensors will tend to become coated by atmospheric borne contaminants, and this will change the absorption and scattering of the emitted light. The optical surfaces are in the same environment within chamber 4 and for each sensor there are the same number of operative optical surfaces for light scattered, reflected or transmitted along a given path. However, it cannot be guaranteed that a given degree of contamination will have an identical effect on both sensor A and sensor B because the sensors operate at different wavelengths. This effect is more significant in the case of the first embodiment, since in the second embodiment there is a separate reference light source for each sensor. It would be expected that contamination would tend to reduce the quiescent signals of the sensors, which mainly derive from light in path 10 for sensor A and in path 11 for sensor B, because the quiescent signals result mainly from reflection off the smooth light coloured surfaces of features 6, 7, 8 and 9. It would also be expected that changes in the smoke signal of each sensor, under given conditions, would be some function of the change in the quiescent signal. The proportional change in the smoke signal is not likely to be identical to that of the quiescent signal. For example, considering sensor A in the first embodiment, there are two common optical surfaces (of light source 1 and receiver 3) which affect both the smoke signal and the quiescent signal, but an additional pair of surfaces (of features 6 and 7) which affect only the quiescent signal. If contamination on each surface were to cause a similar

reduction in signal it would be expected that the reduction in the smoke signal would be proportional to the square root of the reduction in the quiescent signal. In practice, the relationships for typical types of contamination would be established empirically for sensor A and sensor B. According to a further feature of the invention, the quiescent signal of each sensor, measured within a time domain which significantly exceeds that of a developing fire, is used to correct the smoke signal of each sensor, such that the ratio of the smoke sensitivity of sensor A to that of sensor B is maintained approximately constant. A preferred method by which features 6, 7, 8 and 9 may be used to create predictable quiescent signals is to use suitably disposed bright surfaces, as is disclosed in UK patent application GB2342987A.

It will be understood that the embodiments described in the foregoing are given by way of example only, and other arrangements are possible. For example, sensor A and sensor B in combination may employ either one or two light receivers in conjunction with either two or four light sources, i.e. four different combinations as opposed to the two shown. Additional optical elements may be incorporated, e.g. lenses associated with each light source and/or receiver so as to increase the optical efficiency. The principle of operation is not fundamentally dependent on the choice of microcomputer or other electronic components, nor on the detailed implementation of the electronics circuit or operational software, all of which would be known to one skilled in the design of fire detectors. It will be further understood that elements in addition to those described in the foregoing would be necessary to construct a practical fire detector, using components of suitable design mainly of plastic or metal. These would include various mechanical and electronic elements to physically enclose the sensors, mount the detector, and to provide an interface to a fire detection system, such as would be known or obvious to one skilled in the art. Additional sensors using similar or different mechanisms could also be included in the fire detector, e.g. a combustion gas sensor, in order to improve the detection of some types of fire. The ambient atmosphere may be permitted to ingress into the chamber either by natural or forced convection, or by forced flow with the assistance of a pump or fan. Because of its simplicity, the first embodiment is intended to be most suitable for use in a point fire detector based on natural air convection, whilst the second embodiment is preferred for use in a forced air flow aspirating smoke detector, because a higher sensitivity may be practically achieved.

CLAIMS

1 A fire detector wherein the presence of smoke which may ingress into a partly enclosed chamber is sensed by means of light scattered or reflected from smoke or other aerosol particles, characterised in that of any combination of sensors therein, two sensors each employ a light source, the emission wavelengths of these light sources being dissimilar, wherein signals from said two sensors are separately processed within a microcomputer or by similar means, such that the detection of a fire is conditional on there being some signal indicating the presence of smoke (smoke signal) from both of said two sensors, and such that the effective fire detection response threshold value and/or the time delay to alarm varies as a function of the ratio of the smoke signals of said two sensors, in a manner so as to vary the sensitivity of the fire detector to different types of smoke or aerosol.

2 A fire detector according to claim 1, wherein a light source for a first sensor emits at a predominant wavelength which is shorter than that of a light source for a second sensor, and wherein the choice of wavelengths is such that the ratio of the smoke signal of said first sensor to the smoke signal of said second sensor is dependent on the particle sizes in smoke resulting from a range of fire types.

3 A fire detector according to claim 2, wherein a light source for said first sensor emits at a predominant wavelength in the range 400 to 700 nanometers and a light source for said second sensor emits at a predominant wavelength in the range 800 to 1000 nanometers.

4 A fire detector according to claim 2 wherein the effective fire detection response threshold value and/or the time delay to alarm is reduced from normal values as the ratio of the smoke signal of said first sensor to the smoke signal of said second sensor increases, with the intention of increasing the sensitivity to smoke with a smaller average particle size characteristic of a free burning fire.

5 A fire detector according to claim 2 wherein the detection of a fire is inhibited or delayed if the ratio of the smoke signal of said first sensor to the smoke signal of said second sensor exceeds some limit, but there is no corresponding increase in air temperature, measured by means of a thermal sensor incorporated within the fire detector, said air temperature increase being characteristic of the presence of a free burning fire.

6 A fire detector according to claim 2 wherein the effective fire detection response threshold value and/or the time delay to alarm is increased from normal values as the ratio of the smoke signal from said first sensor to the smoke signal from said second sensor reduces, with the intention of reducing the sensitivity to aerosols with a larger average particle size than is characteristic of smoke emanating from a fire.

7 A fire detector according to claim 1 wherein the detection of a fire is conditional on there being coincidences in the temporal properties (frequency components and

phases) of the smoke signals of said two sensors.

8 A fire detector according to claim 1 wherein said two sensors are physically disposed such that the smoke signal from each is predominantly influenced by particles in a different part of said chamber.

9 A fire detector according to claim 1 wherein optical means are incorporated in said chamber, whereby for each of said two sensors a small but stable proportion of the emitted light is transferred from light source to receiver such as to create a predictable quiescent signal, and wherein the value of said quiescent signal measured within a time domain which significantly exceeds that of a developing fire is used to correct the smoke signal of each sensor, such that the relative sensitivity of said two sensors is maintained in the event of changes in the efficiency of light sources or other components, or contamination of optical surfaces associated with the sensors.

10 A fire detector according to any one of claims 1 to 3, wherein said light sources are visible or infrared light emitting diodes and at least one light receiver is a silicon photodiode, and which is provided with suitable optical and mechanical components and associated electronic control means, arranged to accurately control a pulsed electrical current through each light source at different times and to monitor the received signal separately for each sensor.

11 A fire detector according to any one of claims 1 to 10 contained within a mechanical enclosure appropriate for detecting smoke resulting from a fire, and into which the ambient atmosphere may ingress into said chamber through a filter, mesh or baffle, either by natural or forced convection, or by forced flow.

12 A fire detector according to any one of claims 1 to 11 substantially as herein described with reference to figure 1 of the accompanying drawing.

Amendments to the claims have been filed as follows

1 A fire detector wherein the presence of smoke which ingresses into a partly enclosed chamber is sensed by means of light scattered or reflected from smoke or other aerosol particles, wherein of any combination of scattered light sensors therein two sensors each employ a light source, the emission wavelengths of the two light sources being dissimilar, characterised in that the increase in air temperature is sensed by means of a thermal sensor disposed within a part of the fire detector enclosure which is relatively open to the ambient atmosphere, and wherein signals from said scattered light sensors and said thermal sensor are processed within a microcomputer or by similar means, such that the detection of a fire is conditional on there being some signal indicating the presence of smoke (smoke signal) from both scattered light sensors, and that the effective fire detection response threshold value and/or the time delay to detect a fire varies as a function of the magnitudes of the smoke signals of the two scattered light sensors and on the magnitude of the signal of the thermal sensor, in a manner so as to vary the sensitivity of the fire detector to different types of smoke or aerosol.

2 A fire detector according to claim 1 wherein the detection of a fire is conditional on there being coincidences in the temporal properties (frequency components and/or phases) of the smoke signals of said two scattered light sensors.

3 A fire detector according to claim 1 or 2 wherein a light source of a first scattered light sensor emits at a predominant wavelength that is shorter than that of a light source for a second scattered light sensor, and wherein the choice of wavelengths is such that the relative magnitude of the smoke signal of the first scattered light sensor and that of the second scattered light sensor is dependent on the particle sizes in smoke resulting from a range of fire types.

4 A fire detector according to claim 1 or 2 wherein the fire detection response threshold value and/or the time delay to detect a fire is reduced from a normal value if a corresponding signal of the thermal sensor exists that is characteristic of the presence of a free burning fire.

5 A fire detector according to claim 3 wherein the detection of a fire is delayed or inhibited if the ratio of the smoke signal of the first scattered light sensor signal to that of the second scattered light sensor exceeds a defined value, but there is no corresponding signal of the thermal sensor that is characteristic of the presence of a free burning fire.

6 A fire detector according to claim 3 wherein the fire detection response threshold value and/or the time delay to detect a fire is reduced from a normal value as the ratio of the smoke signal of the first scattered light sensor to that of the second scattered light sensor increases above a defined value, so as to increase the sensitivity to smoke with the smaller average particle size that is characteristic of a free burning fire.

7 A fire detector according to claim 3 wherein the fire detection response threshold

value and/or the time delay to detect a fire is increased from a normal value as the ratio of the smoke signal of the first scattered light sensor to that of the second scattered light sensor reduces below a defined value, so as to reduce the sensitivity to aerosols with a larger average particle size than is characteristic of smoke emanating from a fire.

8 A fire detector according to claim 1 wherein said two scattered light sensors are physically disposed such that the smoke signal from each is predominantly influenced by particles in a different part of said chamber.

9 A fire detector according to claim 1 wherein associated with at least one scattered light sensor another light source emits light via a direct path to the light receiver associated with that sensor, the quantities of light emitted by the first light source and this other light source being maintained in a substantially constant ratio, such that a separate reference signal is derived by which means the absolute sensitivity of the sensor is maintained in the event of changes in the efficiency of light sources or other components, or contamination of optical surfaces.

10 A fire detector according to claim 1 wherein optical means are incorporated in said chamber, whereby for each of said two scattered light sensors a small proportion of the emitted light is transferred from light source to receiver such as to create a stable and predictable quiescent signal, and wherein the value of this quiescent signal measured within a time domain which significantly exceeds that of a developing fire is used to correct the smoke signal of each scattered light sensor, such that the relative sensitivity of the sensors is maintained in the event of changes in the efficiency of light sources or other components, or contamination of optical surfaces.

11 A fire detector according to claim 1, 3, 9 or 10 wherein said light sources are visible or infrared light emitting diodes and at least one light receiver is a silicon photodiode, and appropriate optical and mechanical components and associated electronic control means are arranged to accurately control a pulsed electrical current through each light source and to separately monitor received signals for each scattered light sensor.

12 A fire detector according to claim 1, wherein a light source for one scattered light sensor emits at a predominant wavelength in the range 400 to 700 nanometers and a light source for another scattered light sensor emits at a predominant wavelength in the range 800 to 1000 nanometers.

13 A fire detector according to any one of claims 1 to 12 contained within a mechanical enclosure appropriate for detecting smoke resulting from a fire, and into which the ambient atmosphere may ingress into the chamber through a filter, mesh or baffle, either by natural or forced convection, or by forced flow.

14 A fire detector according to any one of claims 1 to 13 substantially as herein described with reference to figure 1 or figure 2 of the accompanying drawing.

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Application No: GB 0300067.6
Claims searched: all
Examiner: Matthew Perkins
Date of search: 7 October 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X, Y	X: 1 to 4, 6, 7, 8 10 & 11 Y: 5	GB 2273769 A	(ELLWOOD & APPLEBY) See abstract, figures, page 3 lines 24 to 39, page 6 lines 44 to 47, page 6 line 55 to page 7 line 1, page 7 lines 18 to 20 and page 7 line 45.
X, Y	X: 1 to 4 & 6 to 11 Y: 5	EP 0877345 A3	(SUZUKI et al.) See abstract, figures 1, 2 & 11, page 4 lines 38 to 42, page 5 lines 37 to 42 and page 9 lines 7 to 29.
X, Y	X: 1 to 4, 6 to 11 Y: 5	WO 00/007161	(RUNCIMAN) See abstract, figures, pages 2 and 3 and page 4 line 18 to page 6 line 5.
X	1	US 5381130	(THUILLARD et al.) See abstract.
X	1 & 7 to 11	US 5008559	(BEYERSDORF) See abstract, figure 3, column 2 lines 46 to 49 and column 4 lines 49 to 54.
Y	5	JP 420068697	(SHIMOMURA) See abstract.

Categories:

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The following online and other databases have been used in the preparation of this search report:

Online: WPI, EPODOC, PAJ